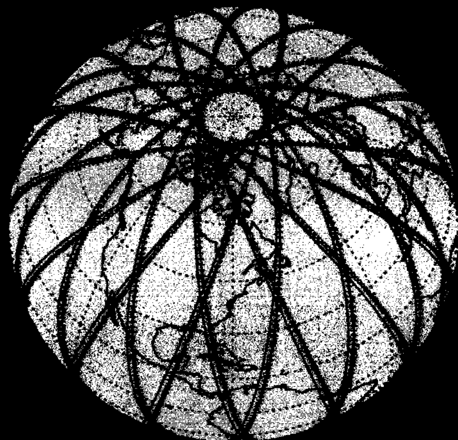
A summary presentation emphasizing the EOS MLS Scientific Objectives, Measurements and Data Products

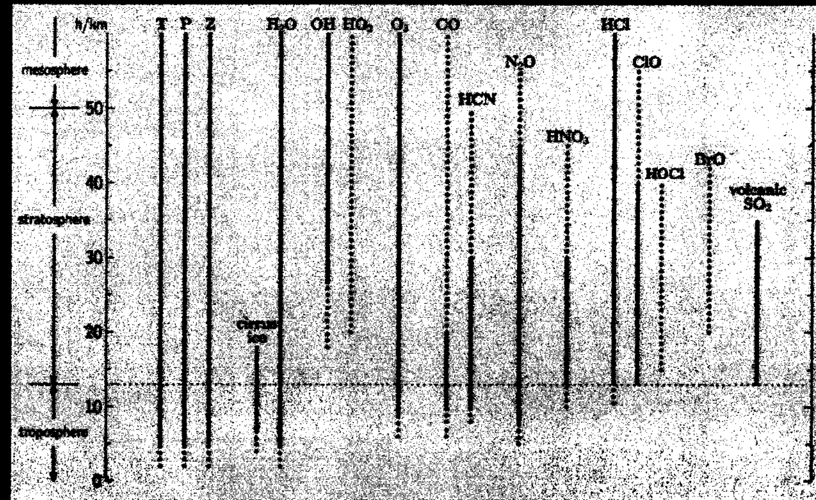
An updated copy of this presentation, and more information on the MLS experiments can be found on the MLS web site: http://mls.jpl.nasa.gov.

***An Overview of the EOS MLS Experiment*, available on the web site, is good starting point for more information on EOS MLS.**

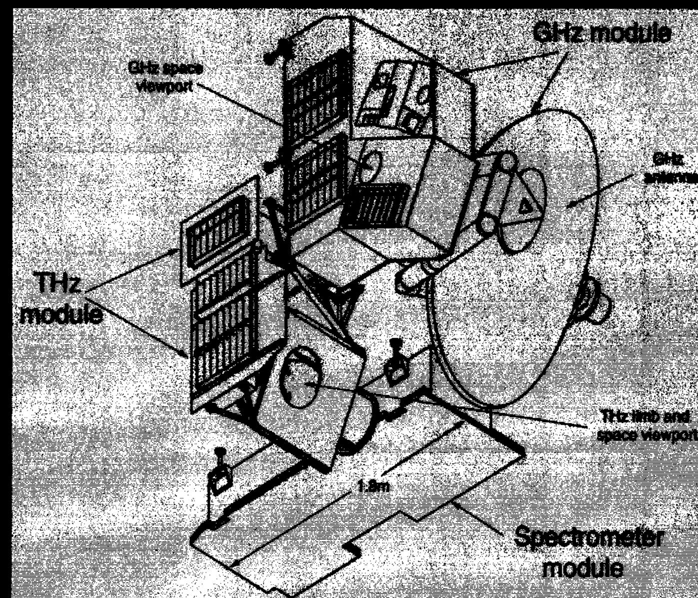
- **Determining if stratospheric ozone is recovering as expected**
- **Improving knowledge of processes that affect climate variability**
- **Helping understand ozone pollution in the upper troposphere**



- **Passive observations of thermal emission from the atmospheric limb**
- **Made day and night**



- **Millimeter and submillimeter wavelength heterodyne radiometers in 5 broad bands:**
  - 118 GHz, primarily for temperature and pressure
  - 190 GHz, primarily for H_2O and HNO_3
  - 240 GHz, primarily for O_3 and CO
  - 640 GHz, primarily for HCl, ClO, BrO, HO_2, N_2O
  - 2.5 THz, primarily for OH
- **On NASA's EOS CHEMISTRY ('CHEM') satellite, to start observations in 2003 with at least 5 years operational lifetime**



- Determining if stratospheric ozone is recovering as expected
- Improving knowledge of processes that affect climate variability
- Helping understand ozone pollution in the upper troposphere

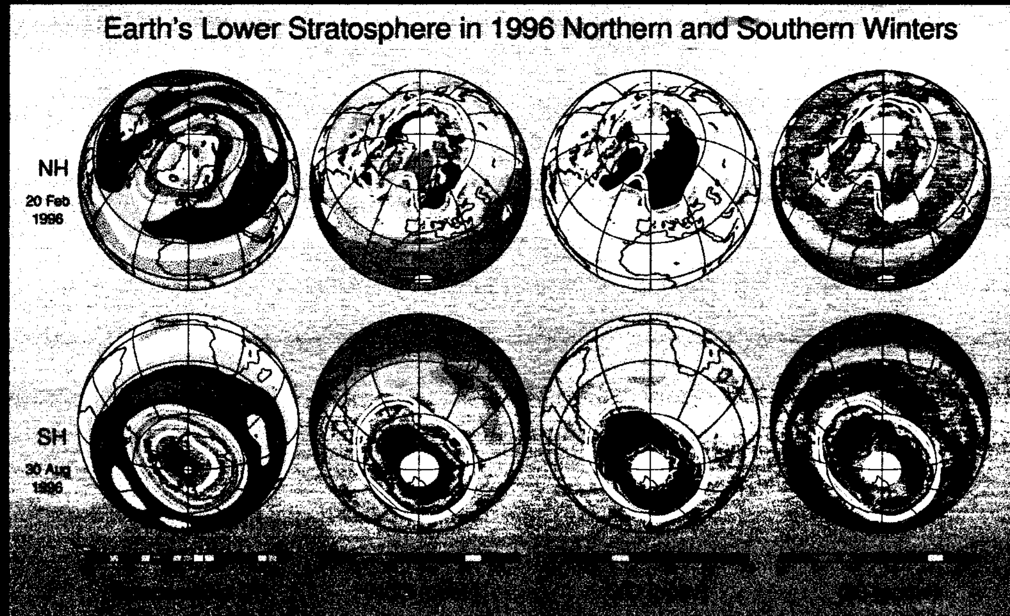
- Together these instruments provide a comprehensive suite of information for helping understand atmospheric global change.

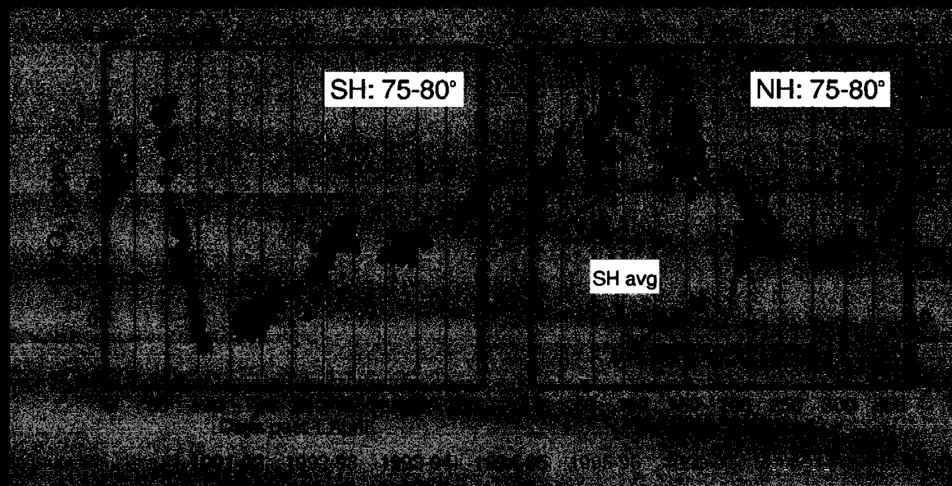
EOS MLS Scientific Objective

Determining if Stratospheric Ozone is Recovering as Expected

- Are stratospheric chlorine, ozone chemistry, and ozone responding to regulations as expected?
- Will ozone recovery be delayed by climate changes?
  - cooling of lower stratosphere
  - increases in stratospheric H_2O
  - changes in atmospheric circulation
- Is Arctic on the verge of severe denitrification that could lead to increased ozone depletion?
  - due to changing climate
- Do we adequately understand chemistry and transport in the stratosphere at all altitudes and latitudes?
- How will volcanoes affect recovery?

UARS MLS HNO_3, ClO, and O_3



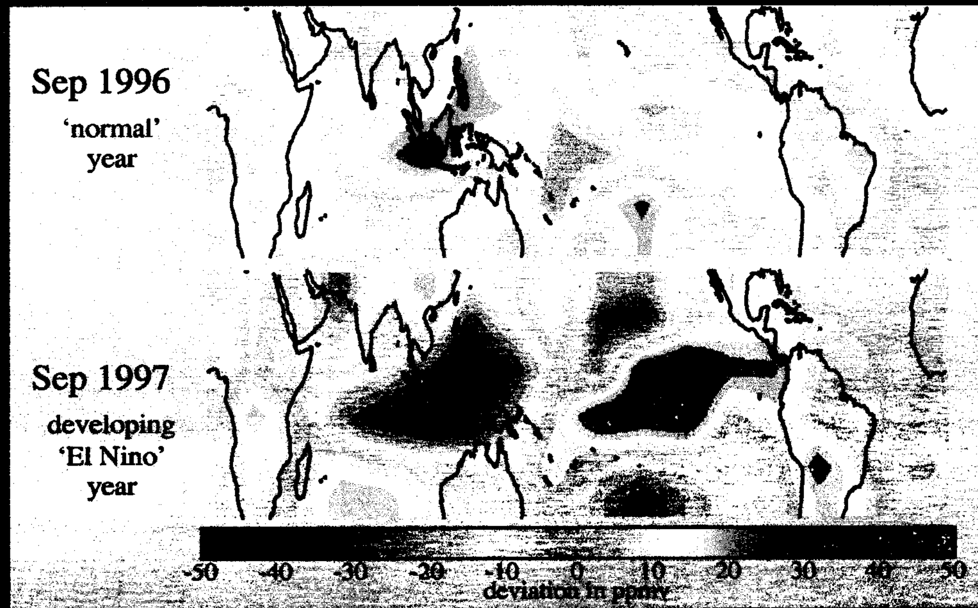


EOS MLS Scientific Objective

Improving Knowledge of Processes Affecting Climate Variability

- How do feedback mechanisms involving upper tropospheric H_2O affect climate variability?
- What are the atmospheric processes that control upper tropospheric H_2O abundances?
- How do variations in sea surface temperature affect upper trop H_2O (and thus climate)?
- How do lower stratospheric H_2O and O_3, and possibly N_2O and Arctic vortex variations, affect climate?

UARS MLS Upper Trop H_2O Variations and El Niño

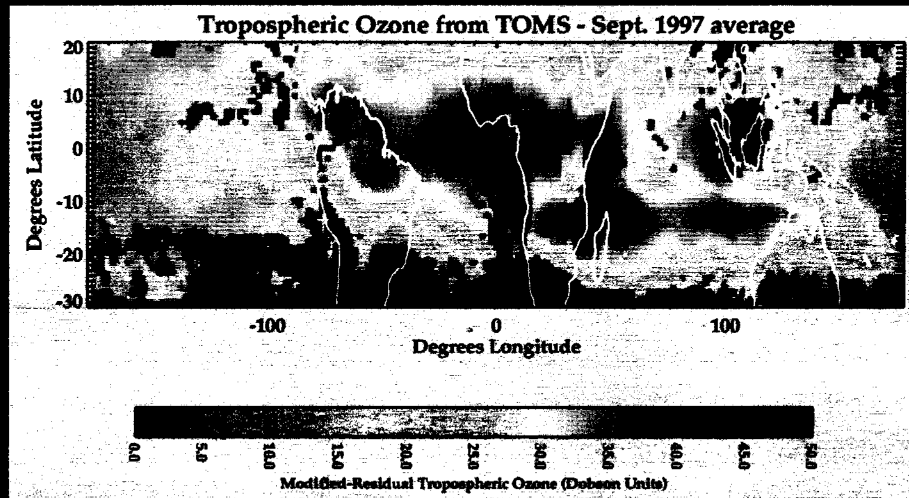


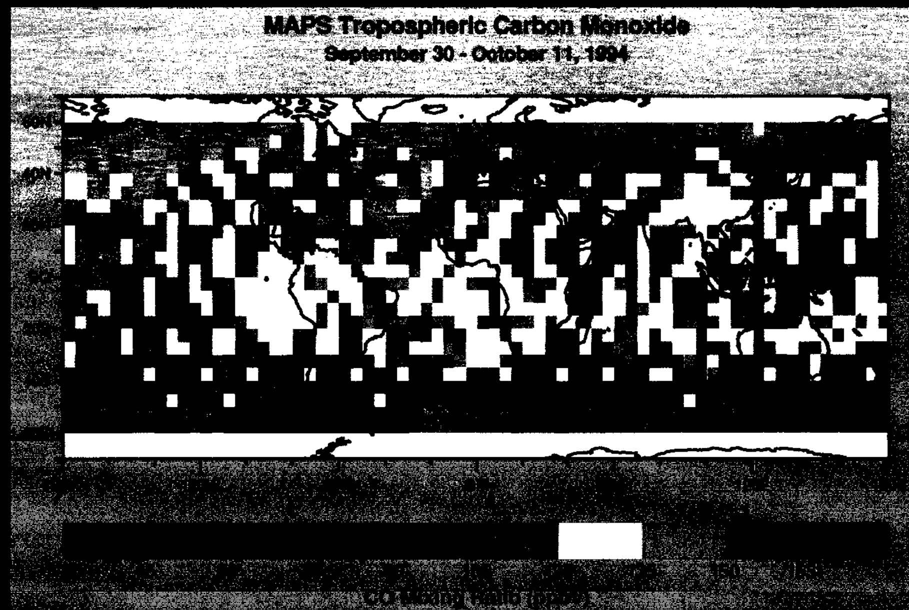
EOS MLS Scientific Objective

Helping Understand Ozone Pollution in Upper Troposphere

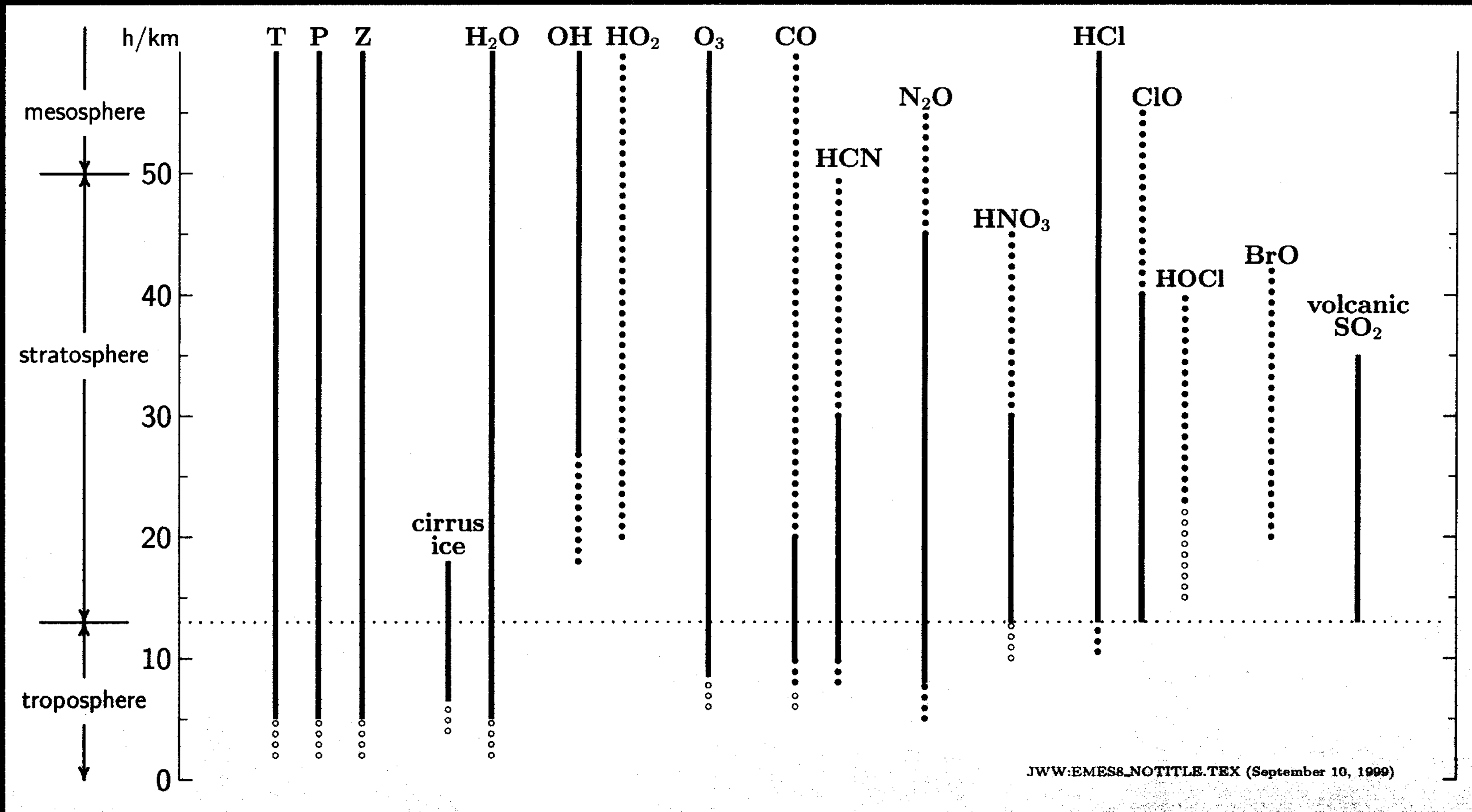
- What is the global distribution and variation of O_3 in the upper troposphere?
- What are the dominant sources of upper tropospheric O_3?
- How is regional pollution related to global upper tropospheric O_3 pollution?
- How might expected increases in upper tropospheric O_3 affect global air quality?

TOMS residual tropospheric O_3 from Anne Thompson, GSFC
MAPS tropospheric CO from Vickie Connors, LaRC





EOS MLS Measurements Summary



Solid lines indicate useful individual profiles or daily global maps (Z is geopotential height).

Dotted lines indicate zonal (or other) averages are expected to be required for useful precision.
Open circles indicate goals for more difficult measurements.
Measurements of T, P, Z, H_2O, O_3, HCl, OH and CO extend higher than the 60 km shown here.
CH_3CN, not yet shown in above plot, will also be measured - based on recent UARS MLS results.

EOS MLS Geophysical Data Products and Files

- Files contain value and precision for each datum
  - Also include diagnostic quantities and ancillary information such as: time, lat, lon, local solar time, local solar zenith angle, line-of-sight angle
  - Vertical coordinate is $\log_{10}(P)$
- Level 2 files
  - Contain individual retrievals, equally-spaced along orbit for normal operation
  - A separate daily file for each standard data product (~2 Mbyte each)
  - Analogous to UARS 'L3AT' files
- Level 3 files
  - Daily maps: separate daily file for each standard data product (~3 Mb each)
  - Monthly maps: monthly file with all std products together (~50 Mb each)
  - Daily / monthly zonal means: daily and monthly files with all standard products grouped together (~3 Mb each)

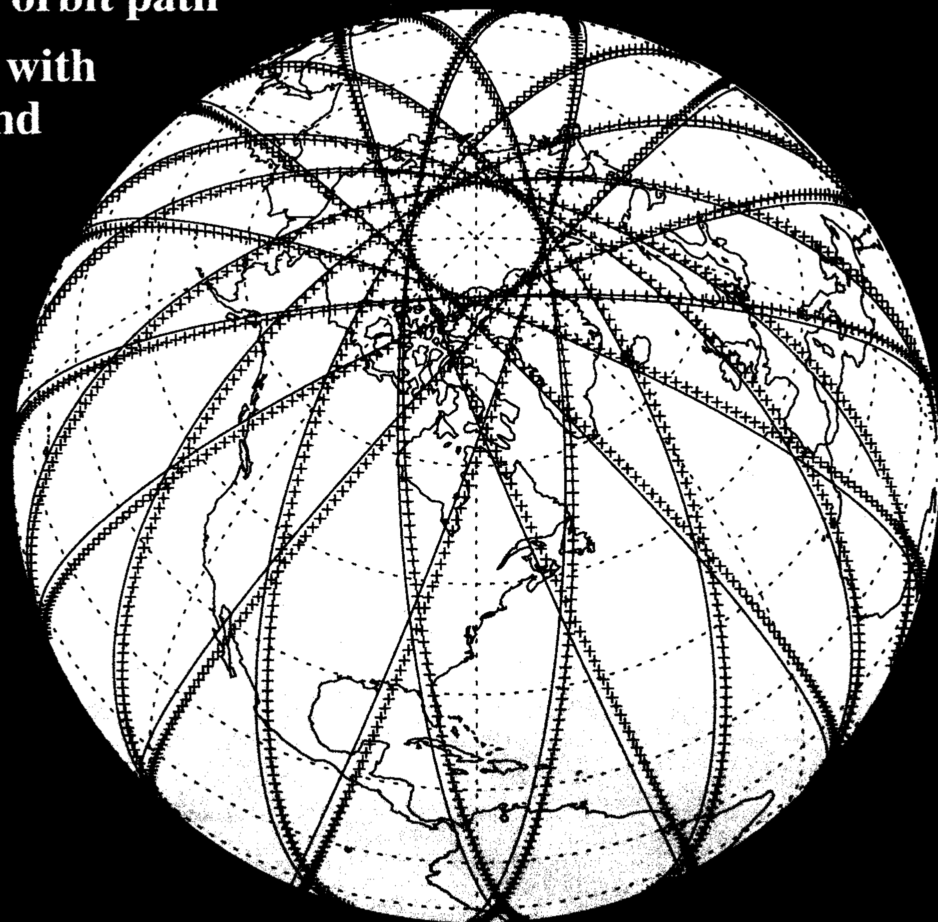
MLS Standard Geophysical Data Products

data product (alphabetical order)	~ useful vertical range			
	pressure / hPa		height / km	
	max	min	min	max
BrO mixing ratio	50	1	20	50
cirrus ice average density	500	50	5	20
ClO mixing ratio	100	0.1	15	65
CO mixing ratio	300	0.001	8	95
geopotential height	500	0.01	5	80
H_2O mixing ratio	500	0.001	5	95
HCl mixing ratio	100	0.01	15	80
HCN mixing ratio	500	1	5	50
HNO_3 mixing ratio	100	1	15	50
HO_2 mixing ratio	50	0.1	20	65
HOCl mixing ratio	25	1	25	50
N_2O mixing ratio	500	1	5	50
O_3 mixing ratio	300	0.001	8	95
O_3 column in stratosphere	(not applicable)		(not applicable)	
OH mixing ratio	50	0.01	20	80
relative humidity w.r.t. ice	500	50	5	20
SO_2 mixing ratio	100	3	15	40
temperature	500	0.001	5	95

Note: CH_3CN will probably be added as a standard product; recent results from UARS MLS indicate that it can be measured by EOS MLS.

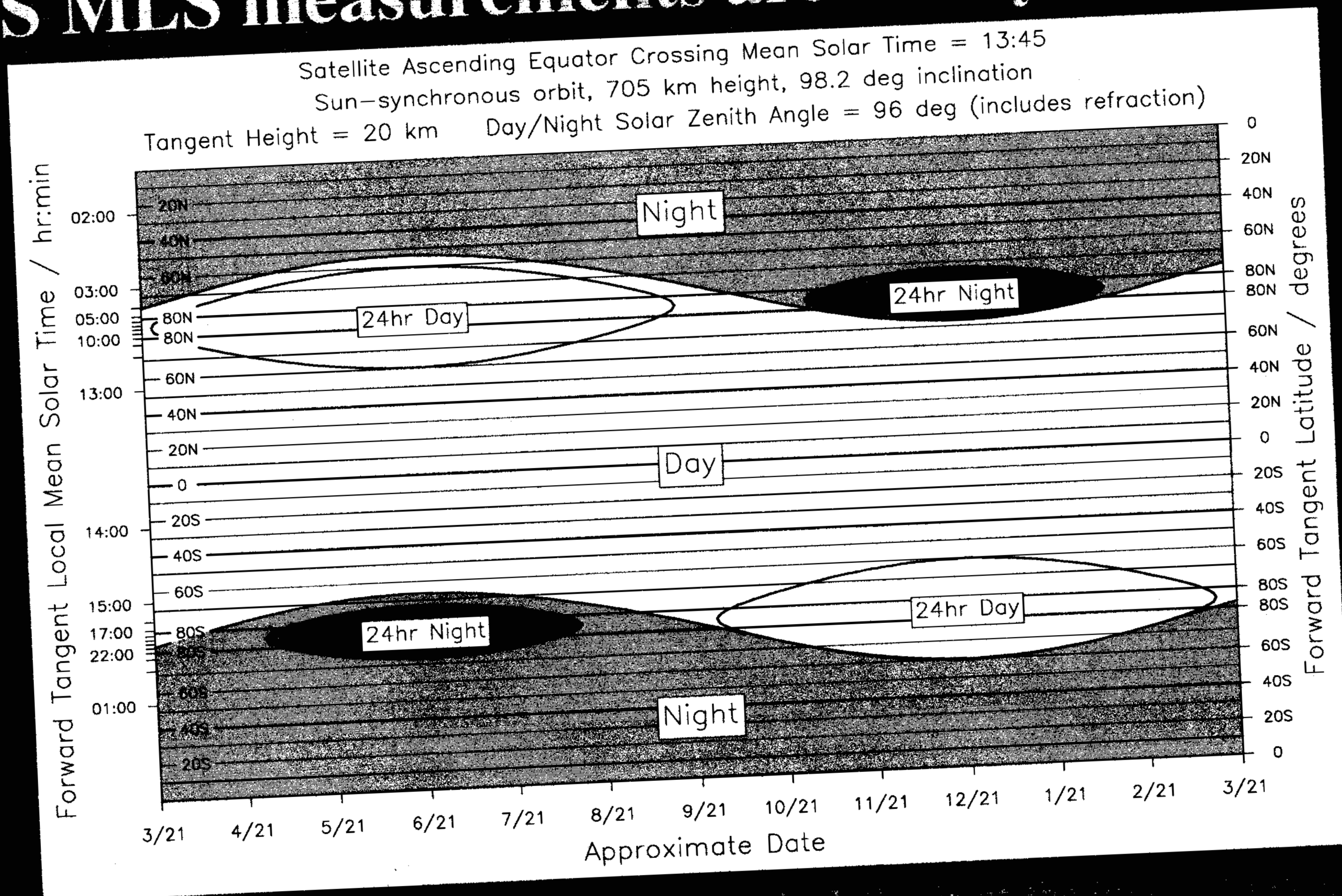
EOS MLS Measurements

- All measurements made continuously, day and night
  - but, if needed to reduce power, can time-share
- Limb scan & calibration each 1.5° along track (each 25 s, 165 km)
  - MLS views in forward direction along orbit path
  - Limb scans are synchronized to orbit, with 240 scans each orbit; scans over EQ and at symmetric latitudes in NH and SH
- Each day's measurement coverage is shown at right
  - each cross gives the location of a limb scan and retrieved profile (line shows subsatellite path)
  - the tangent point locus during each limb scan is nearly vertical
  - Same SH coverage as NH shown here



  - there are resolution vs. precision trade-offs

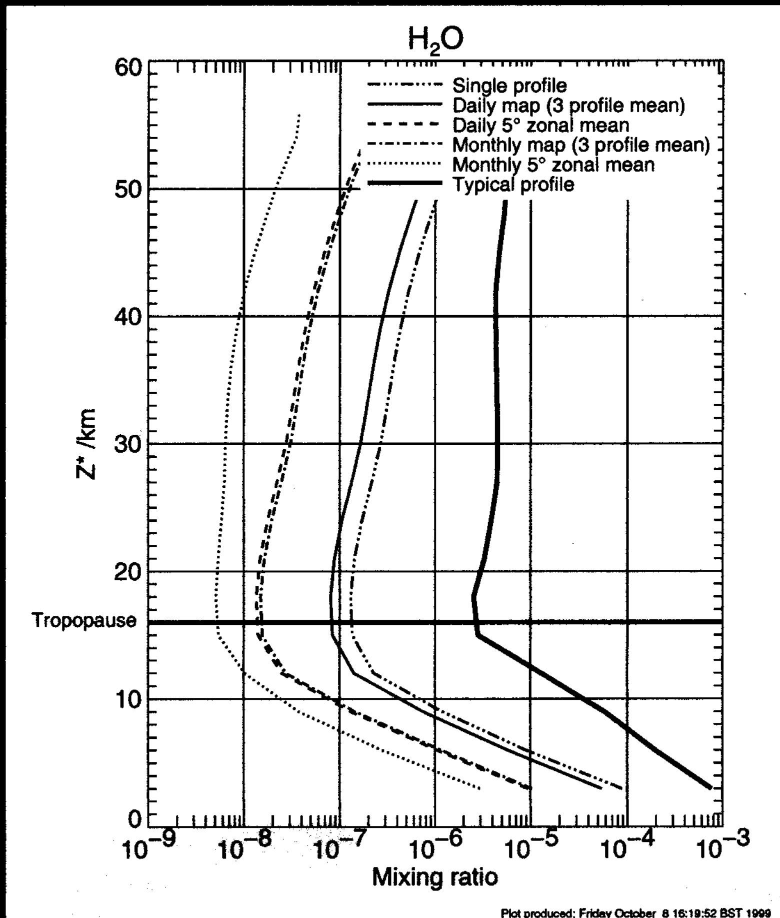
Annual variation of latitude range where EOS MLS measurements are in day and in night



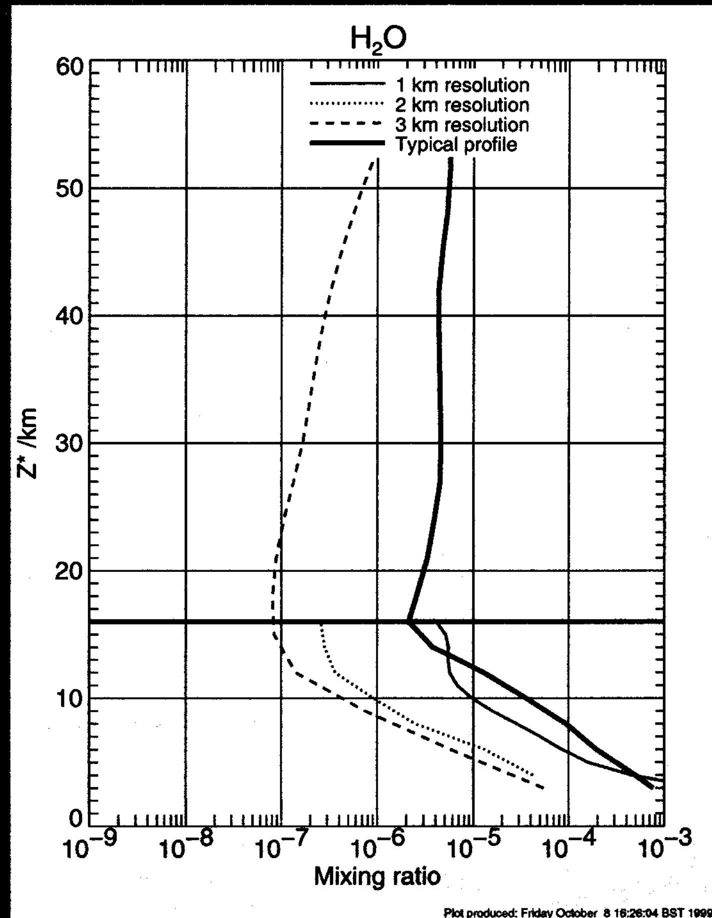
The right vertical axis and horizontal lines give the latitude of the [illegible] where EOS MLS makes measurements; the left axis gives [illegible] except the orbit is in the direction [illegible]

EOS MLS Measurement Precision Example: tropical H_2O

Various H_2O products at 3 km vertical resolution



Daily maps at 3, 2, 1 km vertical resolution in troposphere (and 3 km in stratosphere)



Some features of MLS technique

- **MLS can 'see through' dense aerosol and cirrus**
  - Clouds/aerosol have much smaller effect than at IR, visible, UV wavelengths
  - Some cirrus signals, although optically thin, are measurable by MLS and provide unique ice information
- **Spectral lines are resolved with several channels**
  ⇒ robust data interpretation throughout stratosphere, mesosphere, and most of upper troposphere
  - Continuum emission from H_2O (vapor, ice, liquid) and dry air limits this aspect of robustness at lowest altitudes
- **Accurate and stable calibration**
  - Upper limit of 0.02% change in UARS MLS antenna reflectivity over 5 years in orbit - this is thought to be dominant contributor to overall calibration degradation, and similar performance expected from EOS MLS
  - Composition measurements can be 'self-calibrated' (to ~1%) from temperatur
- **Heritage from UARS MLS (and balloon MLS, [illegible])**
  - More than 180 MLS-related peer-reviewed scientific publications to date (updated list available on MLS web site, http://mls.jpl.nasa.gov)
  - EOS MLS has broader spectral coverage & finer spatial sampling than UARS

The EOS MLS Instrument

- Heterodyne radiometers operating in 5 broad mm/submm bands
  - 118 GHz radiometer: primarily for temperature and tangent pressure reference
  - 190 GHz radiometer: primarily for H_2O and HNO_3
  - 240 GHz radiometer: primarily for O_3 and CO
  - 640 GHz radiometer: primarily for HCl, ClO, BrO, HO_2 and N_2O
  - 2.5 THz radiometer: primarily for OH
- Advanced technology
  - Planar submm mixers
  - Integrated circuits
  - Composite materials
  - Compact gas laser for THz local oscillator and solid-state sources for GHz local oscillators
- JPL designed and developed
  - with many subsystems procured from industry
- Some overall characteristics
  - ~450 kg, ~550 W, 100 kb/s
  - 5-year on-orbit design lifetime
  - Ambient temperature operation